BANDWIDTH SIGNALLING

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TECHNICAL FIELD

The present invention relates to signalling of available bandwidth especially in multicarrier wireless telecommunication systems.

10   ## BACKGROUND

A tendency of new wireless telecommunication systems is that they often require more bandwidth than existing systems, as new and more demanding services are likely to be introduced by the new systems. However, the available spectrum is limited and it is difficult to identify new spectrum for new communication systems, especially if the

15   new spectrum shall be identical in all different regions of the world. This calls for a need of flexibility with respect to spectrum usage in the sense that pieces of radio spectrum of different size and in different frequency bands should be used with basically the same radio air interface.

20   For the sake of example, assume that the most demanding applications require that the system bandwidth needs to be 100 MHz. International standardisation and regulatory bodies will therefore have to make sure that there will be ample spectrum available so that a number of 100 MHz bands could be offered to the customers. However, it is also likely that certain regions will have smaller pieces of spectrum available here and

25   there that are smaller than 100 MHz, say a 30 MHz band in one region and a 66 MHz band in another.

One possibility is to design many different air interfaces for a number of bandwidths - say 30, 66 and 100 MHz - and let the base stations and mobile users choose one or

30   several of them depending on the situation, say a 25 MHz air interface for the 30 MHz band, a 50 MHz interface for the 66 MHz band and 100 MHz interface for the 100 MHz band. This however leaves some parts of the spectrum unused: 5 MHz in the 30 MHz band and 16 MHz in the 66 MHz band, while the 100 MHz band is fully used.

Even if there is a high degree of commonality between different air interfaces, the complexity of equipment with several air interfaces will be significantly larger than if only one air interface can be used instead.

5   Another suggestion for better usage of available frequency spectrum is to let several operators share spectrum or rent or buy resources from each other.

SUMMARY OF THE INVENTION

The proposals and ideas referred to above suffers from a number of drawbacks.
10   Already mentioned is that using different air interfaces in several parts of the spectrum causes greater complexity. Another is that available pieces of spectrum might be too big for certain applications, which leads to a waste of resources. Still another problem is how to inform the users of the existence and extent of free spectrum for a certain application at a certain moment in a certain location area. In other words there is a
15   need for greater flexibility and fast allocation of resources whenever the users so request.

The solution is presented in the appended claims relating to a method and means for signalling the availability of spectrum in terms of bandwidth and location.
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The invention is advantageously implemented in wireless multicarrier system where the total maximum bandwidth is made up of a large number of narrowband sub carriers like for example in Orthogonal Frequency Divisional Multiplexing, OFDM, Interleaved Frequency Divisional Multiplex, IFDM or similar. In OFDM and IFDM
25   the sub carriers are ideally mutually orthogonal. Generally, very similar systems can be designed with pulse shapes that make the sub carriers slightly non-orthogonal but that have other good properties, for example better spectral properties. This difference does not have a bearing on the invention so when OFDM is mentioned in the examples below, also these other more general types of systems are applicable. The
30   only thing that is important is that the system consists of a large number of sub carriers.

With a multicarrier system it is easy to adjust the used system bandwidth by simply switching off some blocks of sub carriers. However, a problem with this solution is how to inform the mobiles about the size and location of the spectrum that is currently used by the communication system. The invention described here solves this problem

5   by including this size and location information within the sub carriers blocks themselves.

The information about which set of downlink carriers in a block that is available is sent downlink from the base station on an acquisition channel, a broadcasting channel

10   or some other cell covering channel. At least one easily detected downlink channel must be transmitted which is within an operational band known to the mobile user and contains information about where this operational band starts and stops relative to the location of said downlink channel. It is enough if the user has a rough idea of where the operational band can be found. This kind of rough information could have been

15   broadcasted to the user in an earlier cell search.

The format of the information about the size and location of the operational band could vary. Here are some examples:

20   •   A start and stop frequency or frequency number is given absolutely or relative to the location of the channel containing this information.

           •   A start frequency or frequency number is given, absolutely or relatively specified, plus a number of maximum carriers or a fraction of that number.

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           •   An identifying number where said identifying number identifies an operational bandwidth from a list of predefined operational bandwidths.

           •   The information about the location in spectrum could be explicitly signalled or

30   implicitly derived by synchronisation signals.

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- As soon as the mobile is informed of the available resources it may access a suitable channel representing its needs in the normal way well known to a person skilled in the art.

5   BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with further aspects and advantages is exemplified by reference to a number of embodiments and accompanying drawings wherein:

Fig 1 shows a frequency spectrum exemplifying bands available in a typical situation.

10   Fig 2 is an overview of the system according to the invention.

Fig 3 is a flow chart showing the steps of the invention in a further embodiment.

DETAILED DESCRIPTION

In Fig 1 a typical spectrum is shown, divided into three blocks or operational bands, I,

15   II and III of 100 MHz, the maximal system bandwidth in this example. The spectrum is partly shared by two operators A and B. A has part I and B has part III while part II is shared between the both operators. It is assumed that, by negotiation between the operators, the border b between A and B is changed from time to time depending on the demand from the subscribers of A and B respectively. The sharing distribution

20   could of course be different. Fig 1 is just an example.

N is the number of sub carriers in each part. Lets assume that the 100 MHz band is divided into 4096 sub carriers of about 25 kHz each, (i.e. $N=4096$). In theory any number N could be activated making a large number of air interface bandwidths

25   possible using just one air interface. This is a basic property of these types of systems. An operator can, at different moments, have say 1000, 2000 or 4000 carriers to its disposal, varying with the demands and behaviours of the subscribers.

Assume that the mobile user knows or can guess the approximate location of all N

30   carriers. First the mobile user must detect the presence of one or more acquisition channel(s) for cell search purposes. Such channels are designed so that there is a very small probability to mistake them for other types of signals, or for other types of signals to be mistaken for acquisition signals. In general the user must scan all

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possible locations to find this signal in order to unambiguously find one. Then the mobile knows that this channel lies within the operational bandwidth. After that, the information in this acquisition channel about the size and location of the actual carrier set is read.

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As an example, the acquisition channel is represented by one or more of the bold marked carriers of block I in Fig 1. Then the information on the acquisition channel tells the user that the band starts at f1 and stops at f2 and that the bandwidth is f2 – f1.

10   Alternatively, based on acquisition channel information, the mobile finds another channel that broadcasts control of the system, and reads the bandwidth information there or part could be read from an acquisition channel and part from another channel that transmits broadcast control information.

15   The system information bold marked carriers are spread out among all possible sub bands of the operational band. Operator A 's signalling is as follows: in the three bold sub carriers to the left in block I, information says that the bandwidth is 100 MHz and all sub bands are used i.e. the whole 100 MHz band, the next three defines a bandwidth of about 70 MHz in block II. Operator B's signalling is as follows: The

20   single bold sub carrier defines a ca 30 MHz system bandwidth in block II, and the next three in block III define a full 100 MHz bandwidth.

Included in Fig 1 is a piece of unused spectrum in block II that comprises a few sub carriers that act as a guard band between the two generally unsynchronised and

25   uncoordinated operators. This is sometimes beneficial in order to reduce the disturbances between the transmitted signals belonging to the two neighbouring sub bands

If the operators, in some real time resource exchange or the like, decide that all

30   bandwidth in the second block II should go to operator A, then operator B simply gracefully finalises or reallocates traffic from the allotted carriers in this block, signals that the resource in block II is closed for random access attempts, and stops

transmitting in this band, while operator A starts to signal that the entire 100 MHz block is now available for its subscribers.

5   Since the terminals periodically read bandwidth information from the downlink control channels, this process could be made very quickly, in the order of milliseconds. Also, the terminals have or could have a full bandwidth detector running which makes it trivial to quickly start (de-) multiplexing data (from) to the newly available sub carriers.

10   In Fig 1 the bandwidth information is repeated in every forth carrier for illustrative purposes as mentioned above. In practice, however, the distribution is much more thinly spread out in order not to waste bandwidth. In a 4096 carrier band the information may be carried on every 128th or 256th carrier occupying less than one percent of the total bandwidth.

15   In Fig 2 an overview of the system according to the invention is shown. A traffic control centre, TCC, is connected over suitable interfaces to a number of base station transceivers BS, only one shown in the figure. The base stations have connections with several mobile stations, MS1 and MS2. The TCC has an over all control of the

20   traffic in the system and one of its tasks is to collect information about the availability of bandwidth of particular parts of radio spectrum used in the system. The information is transferred to the base stations and from there transmitted on a broadcast channel or the like to the users, MS. The TCC is connected to public networks like the Internet. The TCC may also have connections with other TCCs belonging to other operators

25   and after negotiations taking over smaller or greater parts of spectrum from each other.

A user, MS1 in Fig 2 for example, entering the location area of the system scans the broadcast channel(s) sent out by the base station for information about available

30   bandwidth and location in the spectrum according to the invention. MS1, having received the information in receiver R, stores it into a memory M. After entering the scanning is repeatedly performed for changing conditions and the memory is updated.

The invention solves the problem of the need for the mobiles to have knowledge of available bandwidth. The knowledge is collected from a search of the radio environment for the available resources by detecting system information stored in certain sub carriers in the multicarrier operational bands.

In Fig 3, a method for downloading information using the invention is illustrated as a number of steps. In step I, a mobile station, MS, has a need for a multicarrier band with N carriers for the downloading. The MS searches the radio interface in step II. The search is simplified by the fact that information about the size and location of available bands are stored at specified locations throughout the bands e.g. every 128th carrier. The efficiency of the search could be even more enhanced if location and size of suitable bands are prestored in the memory M of the MS. In step III, an N+□ carrier band is assigned to the MS. □ is a small number or zero. MS downloads the information in step IV and thereafter the band could be freed for other users, step V.

To conclude the invention has the following advantages:

- The base station uses basically the same signalling method for any operational bandwidth.

- The mobiles use basically the same detection method for any operational bandwidth.

- The mobile user can use the same detector in OFDM-like systems regardless of the bandwidth used in a specific cell at a specific time

- The mobile user can quickly detect changes in spectrum allocations.

- The invention gives regulators (national or international) flexibility to allocate different sized spectrum pieces for use with basically the same equipment.

- The invention gives operators the technical means to trade spectrum in real time.

- Furthermore, when regulatory conditions change the operational bandwidth can be changed quickly with the mobile station still being able to follow what is happening.

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